* IMPROVING AND ACCELARATING THE PROCESS OF RAISING THE HEARING OF BLINDED PERSONS TO GREATER DEGREE OF USEFULNESS.
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IMPROVING AND ACCELERATING THE PROCESS OF RAISING THE HEARING OF BLINDED PERSONS TO A GREATER DEGREE OF USEFULNESS

A FINAL REPORT

By

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I INTRODUCTION

A. The Problem:

The basic problem of the three-year project at the Cleveland Society for the Blind has been to develop training methods for raising the hearing of blinded persons to a greater degree of usefulness. A newly blinded person tends to use his hearing more than he did as a sighted person and, over the years, develops his hearing to a higher degree of usefulness. The purpose of this project is to determine whether this process can be improved and accelerated by new teaching techniques. The objective is to help blind persons with hearing not only as related to travel, but in all day to day problems in orientation. The problem has been a two-fold one. First, there have been fundamental research and experimental questions; and second, there have been practical teaching problems and experience to be gained from clinical observation. Basically the problem can be stated as the development of training techniques and the testing of these techniques.

One realizes the importance of hearing for orientation when one considers the fact that sight and hearing are the two senses which can efficiently tell us about the world at a distance. Without sight we must depend more and more on hearing to locate and identify things at a distance. The experienced blind person will tell you that he has over the years developed the ability to use his hearing to a high degree. Through experience he has become more efficient in identifying and locating sounds. He has learned to do this better. This does not mean that he can hear a far away pin drop when the rest of us cannot, but he has learned to pay attention to sounds, what they are and where they are.

Space perception and the most efficient location of the sounds are accomplished by binaural or two-eared hearing. Each ear hears the same sound in a slightly different way; the most common physical differences at the ear drums are differences in loudness and arrival time of the sounds. The two slightly different signals are interpreted by higher brain centers. Thus it is that binaural hearing seems to achieve the best space perception.

These facts concerning hearing form the basis for the choice of training technique to study.

Research efforts were concentrated on testing the effectiveness of the use of binaural tape recordings. The binaural tape recordings have been made with two microphones which pick up sound in much the same way as a person's two ears do. The two channels are played back through earphones, one to each ear, so that each ear hears only what the corresponding microphone has picked up. This is different from commercial "stereo," which is recorded with microphones placed some distance apart and then is heard by means of two or more loudspeakers so that sounds from each speaker are heard by both ears. The binaural recordings, not "stereo," are heard just as if each microphone were really one of the person's ears.

B. Project Purposes:

1. To develop the basic recording technique for producing the necessary binaural recordings.

2. To develop a series of binaural recordings for basic hearing training.

3. To develop methods for teaching clients the use of the earphones and recordings.

4. To develop lectures, discussions, and other procedures to accompany the recordings for hearing training.

5. To produce a manual covering the basic procedures based on best research data available.

6. To train personnel at the Cleveland Society for the Blind in the use of the training material.

7. To validate and evaluate the binaural recordings as a technique.

8. To obtain client evaluations of hearing training.

9. To begin a study of head movement as related to listening and the location of sound sources.

10. To continue collection of data on the hearing training of clients in order to know which client factors affect learning to use hearing for orientation; e.g. age, intelligence, amount of residual vision, age blinded, and hearing acuity.

II RESEARCH

A. Equipment and Recordings:

1. General Description:

During the course of the research project different types of equipment were used; for Experiment B described below, compact custom-made apparatus was tried. With the aid of consultants from the American Foundation for the Blind and the assistance of faculty at Case Institute of Technology in Cleveland, adequate instrumentation was secured.

All recordings except for Experiment B were made with a dual channel recorder, a Berlant Deluxe Series 30. The microphones were General Radio condensor microphones (Altec-Lansing type 21-13B, type 1551-P_1). These were inserted in a balsa wood and latex artificial head made along designs of the Bell Telephone Laboratories, and Bolt, Beranek and Newman; the head was supplied by the C.W. Shilling Auditory Research Center, Groton, Connecticut. For listening to recordings Brush Crystal headphones, Serial #378, were used. In the manual there is a list of other appropriate equipment, all relatively expensive and delicate. The main requirement is the precise balance of the two channels throughout both the recording and play-back processes, i.e., throughout the entire system.

At the beginning of the third year of the project the Cleveland Society for the Blind built for research purposes an acoustically treated room. The soundroom is, of course, used for hearing training, for both recording and listening purposes. It is also equipped with twelve simple speakers spaced around the room at regular intervals. From the control room recordings can be played over one, several, or all of the speakers to the client seated in the

center of the soundroom. This speaker system was used primarily in the validation experiment (Experiment C below) to test ability to locate sound sources remote from the individual and to study head movement.

2. The Recordings:

The recordings developed for training are of two kinds. One is a series of the "you are there" type: recordings of familiar sounds, in a kitchen, for example. This series will be added to and improved upon from time to time. There is also a clock-face series designed to give training in location of sound alone. To make these recordings a narrator walked around the artificial head (or "Mike" as it is appropriately called) on a large clock-face drawn on the floor. "Mike" was at the center of the clockface, so that the trainee listening to the recording, experiences the movements of the narrator as though he were himself in the center. The narrator systematically stopped at each clock position. The more difficult locations were repeated.

The clock-face is explained to trainees this way: "Imagine yourself in the center of a large clock-face. You are facing 12 o'clock; 6 o'clock is directly behind you; 3 o'clock is to your right; and 9 o'clock is to your left. It is as if the clock-face were drawn on the floor around you. The narrator will seem to be walking around you on the circle speaking from each clock position." The trainee is asked to point to the direction from which the sound seems to come and to say the clock position.

The information distributed throughout the training recordings consists of the facts on binaural recordings and their use, how we localize objects by sound, how to use the recordings, and how to continue practice in listening.

The following is a summary description of the content and purpose of each recording:*

NAME:	TIME:	DESCRIPTION:
1. Test Tape	3'	For use in adjusting the equipment and balancing the channels. A pure tone.
2. Introduction to Hearing Training	5'30"	The Narrator introduces the listener to the importance of hearing for orientation and to the purpose of the binaural recordings. This could be heard monaurally over a loudspeaker, but the use of earphones helps clients to learn to use them.
3. Clock-face Orientation	16'	The Narrator explains binaural recordings, and teaches the client the clock-face to be used to communicate location. There is also a test of location to provide a before-training score.
4. Around the Clock-Face I	14'30"	The Narrator teaches location by going to each clock position in logical orders. Speech and a low-frequency rattle are used. There are self-tests at intervals since localization improves with practice. Information is included on how we hear binaurally. The clock ticking and sounds of footsteps are occasionally included to allow more sound clues

*Recording speed: 15 ips

NAME:	TIME:	DESCRIPTION:
5. Test 1: Clock-Face Locations	5'35"	The Narrator gives test instructions, then says, "Where am I?" in two series of clock positions. The first is a series of clock positions to the front (180°); the second, to the back. The client is asked to point and say the clock position; he is given the correct answers on the recording.
6. Around the Clock-Face II	9'45"	The Narrator reviews Record 4 and includes self-tests. He illustrates distance from the listener. He illustrates and/or describes the three main ways to locate objects by sound. Clients enjoy repetition of the last part of the recording.
7. Test 2: Clock-Face Locations	10'30"	This is similar to Record 5. However, two series of positions to the front and two series of positions to the back are included. Client can note his own improvement.
8. In the Kitchen	10'	The Narrator describes the situation as a "Friend" makes and serves coffee. Small differences in sounds from different counter surfaces are also illustrated. Client has brief self-tests. He could be instructed to respond aloud to his instructor.
9. In The Living Room	6'45"	This is a recording of sounds often heard in living rooms: serving refreshments, friends talking, a record playing. There is an illustration of locating an object when that object blocks a sound "path."
10. In A Strange Kitchen	8'	The Narrator describes but does not locate sounds in a kitchen. The listener is asked to locate the typical "furnishings" of a kitchen, then he is told the answers. The client is encouraged in the future to know a new room by listening to typical sounds of each type of room or place.

In the Appendix are copies of the scripts of Recordings # 6 and # 8. Several sets of recordings are similar to each other. The one main difference in the final recordings as contrasted to earlier ones is the additional information which is always given concerning sound sources, that is, whether sounds are coming from back or front. In the first series of recordings this information was omitted and the usual front-back ambiguity of binaural recordings resulted. The simple addition of front-back information almost entirely eliminates the front-back errors in a short time.

The other main difference in the final recordings and earlier ones lies in the type of directions given to clients, in the exact wordings of information, etc. The first series acted as pretests for such directions and information.

The manual states that there will be additional recordings of the "you-are-there" type. These should be largely of traffic sounds; at present we have good experimental recordings of traffic but not recordings which are adequately produced and edited for training purposes.

3. Discussion:

In the manual there is this important note: "To use or evaluate the tape recordings which are described in the manual, it is imperative that properly constructed and balanced equipment be used. Ordinary stereophonic equipment will not be satisfactory." This emphasizes the fact that precision instrumentation is required. An expert technician must balance the two channels carefully to control the intensity balance of the two channels and to correct for phase differences. Unless delicate channel balance is maintained the location of sound sources seems to shift.

The tape of pure tone is provided for balancing the channels. It is primarily for the technician's use; however, it also provides a subjective method for balancing the channels. When one listens to the tone over both channels it should sound "centered" when the channels are balanced. Two defects in binaural recordings heard with earphones have been corrected with simple instructions. First, if a listener turns his head, the whole sound world turns with him. He must be instructed not to turn his head while listening with earphones. Second, there is front-back ambiguity of sound which is resolved in real life by turning our heads. Since it is the relationship of sound in the two ears which cues localization, one readily sees that on the imaginary clock-face, 12 o'clock and 6 o'clock would sound alike. So would 1 o'clock and 5 o'clock; 11 o'clock and 7 o'clock, etc. As has been mentioned, simply telling the listener that the sounds will be coming from the front (or back) frees him from the ambiguity and makes meaningful training possible. When he tries to imagine the situation and has some practice in listening over the earphones, the trainee has little difficulty.

In listening the earphones must fit perfectly over each ear and not be the least bit crooked; otherwise, apparent shifts in the location of sound sources will occur.

Concerning the recording process and placement of microphones, we have followed the advice of A. William Mills, formerly of Harvard Psycho-Acoustic Laboratories and now at Tufts College: "I do not know of any systematic experimental data on the effects of microphone placement on the realism of directional sound reproduction. If the recordings are for binaural reproduction (that is, to be played over a separate pair of earphones worn by each listener) there is no evidence of a better way of placing the microphones than at the ears of a

dummy head. When this technique is used with high fidelity equipment it can scarcely be distinguished from the real thing."

B. The Experiments

1. Summary

Validation:

For these experiments, orientation of a subject was operationally defined as his ability to locate and identify sounds. Localization and identification of sounds on the recordings improve significantly with the use of binaural recordings. Learning curves show significant improvement throughout a series of five tests of 20 trainees in locating the recorded sound sources heard by use of earphones. (Experiment B)

Training by means of the recordings also resulted in significantly better localization of sounds heard through loudspeakers remote from the subjects. (Experiment C.) There was no significant difference in improvement between earphone trained subjects and subjects trained by means of the speakers several feet remote from them.

The validation of the use of binaural recordings was also demonstrated by comparing ability to interpret real traffic sounds and ability to interpret similar recorded sounds. For the latter validation an experienced blind traveler was given a number of trials at a busy street corner. At the "start" signal she was to listen carefully and say "now" when it was safe to cross the street in front of her. Traffic sounds from that corner were recorded. The subject's responses when listening to recorded traffic sounds were not quite as good as but were not significantly different from her performance in the real situation.

Identification of Sounds:

No statistics are necessary to clarify results in sound identification. Ordinary familiar sounds which were presented to subjects were learned after one presentation of the sound illustrating the high level of recorded fidelity. The evidence points to the conclusion that we can, within limits, choose what we want a trainee to learn in sounds and give him experience in that listening.

Overcoming front-back ambiguity:

In Experiment C it was found that the front-back errors described earlier were eliminated by the second training session. In that experiment trainees were always told when sounds would be coming from the front (or back) half-circle. At first, even though this information was given the front-back ambiguity was compelling. In earlier experiments when subjects were not told the location of sound sources, the front-back errors continued to occur. Evidently it takes a little while to become accustomed to imagining the situation "to the front" or "to the back."

Trainee evaluation of hearing training:

Trainees have evaluated hearing training in terms that are both positive and helpful. Most trainees think that "most" blind persons would benefit from such training. Most trainees think that those that are totally blind would benefit more than those that are partially blind but many say that the partially blind "should" benefit but would not. A large number mentioned that for good orientation two things were important: (1) a "map" in the head and (2) sounds as reference points in that map. Their list of "important sounds

to record" include for the most part everyday sounds which seem to function as reference points. Trainees, as well as researchers, seem to think that in the training session the most useful information to be given them concerns (1) two-eared hearing and location (2) the use of head turning (3) the use of sound reflections, i.e., echolocation techniques (4) methods for the continued development of the use of hearing.

Head movements:

Motion pictures of several trainees in the soundroom were made from the control room as the trainees attempted to locate sounds from the twelve speakers located at regular intervals around them. The two main purposes for the motion pictures were (1) to pretest the particular method of motion pictures for measuring, recording, and timing head movement in relation to known sounds, and (2) to have a series of observations which could be carefully analyzed in order to form hypotheses which could then be experimentally tested.

The motion pictures as shot through a wire grid serve only to record gross movements. Refinements must be made in measurement, especially since small, involuntary movements, as well as gross voluntary movements, seem important in sound localization. Several hypotheses for further research are explained below in section 7.

2. Maze Performance and Binaural Recording Training (Experiment A; 1958)

a. Introduction

The purpose of this experiment was to study the effects of training by means of binaural recordings on the foot-travel behavior of normal subjects. The hypothesis was that subjects who received preliminary experience listening to the recorded localizing cues would perform differently in a travel situation from subjects who did not receive such training.

b. Method

A "maze" was set up consisting of speakers set at various positions in a suite of rooms (Appendix 4). A master switch fed a signal to the speakers in any pattern desired. The binaural recording apparatus was rolled through the suite of rooms in a pre-determined manner while appropriate speakers were switched on and off. Thus the sound cues on the recording would be the same ones available to the subject as he navigated the maze.

The sound used was a ten second pulse train, a signal which is relatively easy to localize. The training recordings consisted of a spoken commentary describing the situation together with the recorded localizing cues.

The training recording:

"The study in which you are participating is designed to find out something about how people learn to listen carefully. It is sponsored by the Society for the Blind. The results will be applied to the training of newly blinded people who must learn to travel from place to place and room to room without the benefit of vision. You must not discuss this experiment outside of this room, since the performance of future subjects may be affected by what they hear from you.

You will hear a sputtering sound coming from various places around you. It will sound like this. (five seconds of sound.)

The sound will appear to be moving toward you, but, if you will use a bit of imagination, you can make it seem as though you are moving toward the sound.

Here is a short sample of what you will hear. Imagine that the sound is standing still and you are walking toward it. (fifteen seconds of sound.)

Now suppose that the sound is off to one side and you must turn to face it before you can walk toward it. Listen carefully; the sound is opposite one ear at first; then you turn toward it and start to walk. (twenty seconds of sound.)

Now, here's a different sound. Listen to it and see if you can tell what the difference is. (five seconds of sound.)

Did you notice that the sound was muffled? That probably means that it is in another room. Listen again. (five seconds of sound.)

Now, when you hear the muffled sound, walk toward it until you come to the doorway; then, when you are through the door, turn to face the sound, and walk toward it again. Listen closely. (twenty seconds of sound.)

Listen to that one again. (twenty seconds of sound)

This time, when you reach the sound source, it will stop, and another sound will start. Listen now -- first you turn and walk toward the sound. When you are very close to it, stop. Then, when the new sound starts, turn and walk toward it. (thirty seconds of sound)

You have now heard <u>all</u> the various ways in which the sounds will differ, depending on where they are in relation to your head. This time, you will walk through a series of rooms, from sound to sound, through doors, around corners, and so on."

There follows a 6 minute 55 second recording of a walk through the three room maze with occasional comments about doorways and turns. After a short silence the recording continues with a nine question quiz asking whether sample sounds are from the right or left, front or side, same room or different room. The total duration of the recording is 9 minutes and 30 seconds.

Procedure:

Two groups of subjects, normal sighted adults, were used, an experimental group which received the record training and a control group which had no preliminary listening experience. Both of these groups were required to negotiate the maze blindfolded listening to the sound cues. Every subject was seen four times. For the experimental group the first and second times were training sessions. The third session included training and a first attempt to negotiate a maze. In the fourth session subjects of the experimental group had only to walk through a second maze. In each of the first two training sessions subjects listened to 9½ minutes of recording. For the third training session, however, the quiz portion of the tape was deleted so that a subject listened for only 6 minutes and 55 seconds. Total listening time was

approximately 26 minutes. The control group performed in the same two mazes and in two more as well.

The first maze was composed of six "legs;" the second maze was also composed of six "legs" in a slightly different order. Using Appendix 4, note the paths of the mazes from one speaker to another. The legs of Maze 1 are as follows: S to Z, Z to X, X to W, W to V, V to W, W to Y. The legs of Maze 2 are as follows: S to X, X to Y, Y to W, W to V, V to X, X to Z. The measure of proficiency in travelling through the maze was the time to the nearest second to move from one speaker position to another. The distance between successive speaker locations constituted one "leg" of the maze.

Instructions to Subjects:

The following instructions were read to each subject before each trial of walking through a maze. He was carefully positioned on a starting line while blindfolded, and then was given these instructions: "Stand right here. You will hear sounds coming from various places around you. When you hear a sound, start, walk toward it until you feel you are very close, then stop. If you get too close, the sound will stop. Whenever the sound stops, you stop, too. When a new sound starts, turn and walk toward it. Try to go as fast and accurately as you can. Are there any questions?"

c. Results

Appendix 5 summarizes the results. The time taken by each subject to traverse each leg of the maze was measured to the nearest second. Mean time for each group to traverse each leg of the mazes was determined. The results of *t* tests which were used to compare experimental group means with control group means are included in Appendix 5. They indicate a significant difference for all legs between the means of the two groups at the 5% level of confidence or better. The experimental group took significantly longer for each leg than the control group.

d. Discussion and Conclusions:

It is obvious that training with binaural recordings, even for the short periods of time involved in this study, can and does change behavior though not in the directions the experimenters expected. It is interesting that the experimental group, not the control group, took a significantly longer time to negotiate the legs of the mazes. This result has serious implications for the measurement of travel ability or mobility.

Why did this result occur? Perhaps it indicates a negative value for training. On the other hand, perhaps the explanation is that the trained subjects took time to listen more carefully and to think out the cues before moving. In a real life situation these experienced subjects, although they might move more slowly, might be in a better position to face new situations since they would attend to sounds more analytically and intelligently.

3. Improving the Use of Hearing with Binaural Recordings (Experiment B; 1959)*

a. Introduction

Our research problem was to answer several questions. Will localization and identification of sounds improve with training? More

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*The article in the New Outlook, June, 1960, is freely quoted and/or paraphrased.

specifically, can binaural tape recordings be used in training for localization and identification of sounds? Do our methods raise interest and motivate the client to better listening? Will he pay more attention to his hearing for better orientation?

b. Method

Recordings for this experiment were similar to those described in Section A. The following is a list and description of the recordings used for experimental purposes:

1. Adjust And Pretest (APT-10 minutes). To allow trainee to adjust to use of headset, and to adjust volume; to orient trainee in the clock-face convention; to provide the first score on location of sound before training.

2 and 3. Clock-Face Training (CFTR 1 and CFTR 2 -- 12 ½ minutes each). Two recordings which go through systematic teaching procedures on the clock-face with speech and a low-frequency rattle.

4 and 5. Clock-Face Tests 1 and 2 (CFT 1 and CFT 2 -- 7 minutes each). Two recordings to test ability to locate sound. Each contains two tests, two complete series of clock-hour positions with the narrator asking "Where am I?" (1, 4, and 5 contain a total of five localization tests.)

6. Kitchen Training (KTR 1 - 10 minutes). A recording in which kitchen sounds are described by the narrator as they are heard.

7. Kitchen Test (KT 1 - 7 minutes). Designed to test location and identification of kitchen sounds.

8. Kitchen Test (KT 2 - 9 minutes). Someone prepares instant coffee. Questions are then asked about location and identification of things in the kitchen.

A monaural recording was also used for sound indentification only. There was a training section in which the sounds were identified by the narrator and there was a test section. The sounds included such familiar ones as a typewriter, a diesel-powered locomotive, a revolving door, and a motorboat in water.

Subjects:

Twenty trainees from the New York Lighthouse and the Cleveland Society for the Blind were selected to serve as subjects. They were divided into two groups -- the Experimental (E) and the Control (C) groups. All subjects had normal balanced hearing and were between 18 and 55 years of age. The two groups were matched in range and level of intelligence, length of time blinded, and amount of residual vision.

Experimental Testing and Training Procedures:

The experimental group received the training first, then was tested. The control group was tested without receiving the training, although training was given later. Both groups were exposed to the Adjust and Pretest (APT) recording in the first training session in order to have pre-training localization scores for all.

There were three training sessions for each individual. The sessions were usually two, and occasionally three, days apart. They consisted of:

EXPERIMENTAL GROUP:

Session I

1. General introduction to the procedure and establishment of rapport with the instructor.
2. Recording APT (one localization test).
3. Discussion on hearing: information on how we hear, what experienced blind persons can do, echolocation or sonar techniques, what are trainee's experiences with sounds. Purpose: to inform and to motivate.
4. Recording CFTR 1.
5. Trainee's experiences: Instructor listens and guides trainee's ideas.
6. Assignment of homework in listening to sounds in the home.

Session II

1. Review of discussion in Session I.
2. Recording CFTR 2.
3. Recording CFT 1 (two localization tests)
4. Recording KTR 1.
5. Discussion, if trainee were interested.
6. Assignment of homework in listening to sounds outside.

Session III

1. Brief discussion of homework
2. Monaural recording
3. Recording KT 1
4. Recording CFT 2 (two localization tests)
5. Recording KT 2.
6. Trainee's evaluation of hearing training.

CONTROL GROUP:

Session I

1. General introduction as for E group
2. Recording APT
3. Recording CFT 1
4. Monaural test

Session II

1. Recording CFT 2
2. Recording KT 1
3. Recording KT 2
4. Recording CFTR 1

Session III

1. Discussion on hearing as for E group
2. Recording KTR 1
3. Recording CFTR 2
4. Trainee's evaluation of hearing training

Great care was taken not to rush into the testing for the control group. No trainee was tested until the instructor judged him to be at ease and relaxed in the testing situation. The APT recording served well to create an interesting situation.

c. Results

Sound Identification:

No complicated statistics are necessary to clarify results in sound identification. A cursory look at the data is enough. The sound identification recordings have so far been of such ordinary, well-known sounds, that almost all trainees in both groups could identify them at a 100% level after one presentation.

Sound Localization:

The data show generally that localization of sound via binaural recordings will improve with practice, but there is a limitation. In using the binaural recordings errors in front-back localization are made. This means, for example, that twelve o'clock (center front) and six o'clock (center back) are confused about 50 per cent of the time. This is an error which is perfectly "natural." It is due to the relative signals in the two ears, twelve o'clock sounding the same (equally loud, etc.) in both ears and six o'clock also sounding the same in both ears. The front-back errors do not stop there. Remembering the imaginary clock-face on the floor around us, and remembering our position as always facing twelve o'clock, we can readily see that one o'clock (right front) and five o'clock (right rear) will also be confused, since there again is the similar relationship of sound signals in the two ears. (For example, sounds from one and five are slightly louder in the right ear and reach the right ear a fraction of a second sooner.) Results show this front-back error for positions twelve and six, one and five, two and four, eleven and seven, ten and eight. A left-right error is very rarely made. The three (directly right) and nine (directly left) can be slightly misplaced toward front or back, but the sides are not reversed.

In order to take into consideration the facts of front-back localization, two measures were used to score localization results. Measure a is the mean clock-hour error. If the correct answer was four o'clock and the trainee answered 5 o'clock, this counted as one clock-hour of error. For each test the mean (average) of these errors was calculated for the individuals and then for the group. Measure b is the corrected mean clock-hour error. Scores were calculated as if either twelve or six were correct for twelve and six, as if either two or four were correct for two and four, etc.. This method of scoring controls statistically the front-back errors. It is as if the circle of the clock-face were converted to a half-circle.

Results and analyses of the five clock-face tests are shown in Appendices 6, 7, and 8. For brevity only analyses of measure b are tabulated since there are no statistically significant differences between any groups or any tests when measure a is analysed. There is a definite improvement of scores with practice. Appendix 6 shows the group means for each test. The statistic t is used for analysis to compare the experimental (E) group (trained) with the control (C) group (untrained). Appendix 7 shows t's which indicate comparison of one test with another. Appendix 8 reports results of the analysis of variance.

In Appendix 6 note the improvement of mean scores from Test 1 to Test 5. For E group, errors dropped from a mean of 1.27 to .79; for C group, errors dropped from .95 to .79. The improvement with practice occurred with both the E group and the C group. The analysis of variance (Appendix 8)

shows the difference on all five localization tests between the E and C groups is not highly significant, but that there are significant differences among trials (or tests, in this case). But two facts remain. Test 1 (the pretest) showed that the C group, which received no training, was significantly better than the E group to begin with; and yet the group means for E and C are the same (.79) on Test 5, the last test. For E group the difference between Test 1 and Test 5 is highly significant at the 2 per cent level (Appendix 7); for C group this difference is significant but only at the 10 per cent level (also Appendix 7). E group improved somewhat more rapidly with the same amount of practice.

d. Discussion and Conclusions

The success of training blind persons in sound identification rests primarily in the fidelity of recording equipment and also in the choice of sounds presented to the trainees. Every worker with the blind, every expert blind traveler, and every researcher has his own idea of the sounds to be presented to the trainee. It seems important to come to some agreement in these opinions and to present the full range to the trainees. Results seem to indicate that experience in listening helps in learning to identify any sounds within the limits of human auditory response and discrimination.

We can conclude that training in localization was accomplished via binaural recording. Just taking the tests, which is actual practice in localization, provided a certain amount of effective training. Simple localization of speech sounds and a low frequency rattle improved with successive tests.

Both the Experimental and Control groups improved significantly in localization ability. The difference between the two groups lay primarily in the fact that the Experimental group was given simple information on hearing and its use. This factor seemed to have little added effect on localization ability or its improvement, but there is a question concerning its effect on interest of individuals in continuing to learn to use hearing and on their motivation. In the Experimental group there was much more discussion; their statements and questions seemed to be related to the information which they were given. It is for this reason that simple information and opportunity for discussion are always included in present hearing training and in present research on hearing training.

Front-Back errors were a big problem in the binaural recordings as made for Experiment B. The simplest explanation for these errors lies most likely in the fact that in listening to binaural recordings via headphones, there is no way to turn the head for another "point of view" of the sound. Head turning, even very slight, involuntary head turning, usually affords the adequate cue to correct front-back localization.

The front-back problem is one limitation to binaural recordings for headphone use. Many solutions will be attempted by means of electronic and recording techniques, but experience seemed to indicate that, if the listener knows whether the sounds are coming from front or back, he experiences little difficulty in perceiving the sounds as being from that direction. Since training depends on this perception, it was planned that with present standard recording techniques quite satisfactory recordings for localization tests would be made in the future in the half-circle (180°) in front or in back of the microphones and trainees would be so informed. Experiment C reported next, was designed in part to validate this.

In response to evaluation questions, which were carefully worded and pretested to avoid influencing the answers, each trainee stated that the training had made him "more conscious" of the use of hearing or had "emphasized" it. Trainees agree that the training would be useful to "most" or "all" blind people when the choices are "all", "most", "about half", "a few", or "none". Many who seemed to express themselves readily reported that the information most useful to them concerned two-eared hearing, head turning, the use of sound reflections or echolocation techniques, and the possibility of the continued development of the use of hearing.

4. Improving the Localization of Remote Sound Sources: A Validation (Experiment C; 1960)

a. Introduction

Experiment B established the fact that a subject's ability to localize recorded sound sources improves with training using binaural recordings and earphones. The next question was: Does training of this type help the subject locate sounds in real life, i.e., sounds which are heard through normal space and not through earphones? Experiment C was designed to answer this question. In addition, the experimental design was devised to answer questions concerning the front-back problem which had become so evident. Could front-back errors be overcome for training purposes while using standard recording procedure?

b. Method

Twenty-four blind persons, the subjects for Experiment C, were given hearing training in localization. Half of them (Group A) were trained by the binaural clock-face recordings and headphones used in Experiment B. The other half (Group B) received clock-face training over 12 speakers located equidistantly around them in the sound room. (This arrangement was described in Section A of this report.) All subjects received informal, but standardized, lectures on hearing and its use in orientation and discussed their experiences with the experimenter. Prior to training, all were pretested for their ability to localize sounds with both earphones and speaker systems. After training, final localization tests were given by both speakers and earphones. The order of the tests (2 pretests and 2 final tests) was randomized.

Subjects:

All subjects had normal, balanced hearing and were totally blind, i.e., were not able to use vision for orientation. They were between 18 and 60 years of age. They were assigned at random to the two groups. Although some of the subjects had been blind for several years, only two traveled independently outside their own homes. One of these was assigned to Group A; the other, to Group B. One subject in Group A was not able to learn what was required of him; therefore, his scores were not included in the analyses of results.

Experimental Procedure:

Two one-hour sessions two days apart were required. After localization training and testing, each client, in order to complete hearing training, listened also to the "you-are-there" recordings described in Section A. All training took place in the sound-room. The following is an outline of procedure:

GROUP A:
Session I

1. General orientation and establishment of rapport
2. Earphone presentation of the use of the clock-face
3. Pretests in localization: speaker and earphone presentations
4. Discussion on hearing (as for Experiment B)
5. The first clock-face training recording (CFTR-1) There is systematic presentation of speech and low-frequency rattle from all clock-face positions.
6. A clock-face test of localization (CFT-1) It includes a series of the 7 positions in the front half-circle and a series of the 7 positions in the back half-circle for the subject to locate
7. Discussion of trainees' experiences
8. Assignment of homework in listening to sounds in the home

Session II

1. The second clock-face training recording (CFTR-2) This is similar to the first clock-face training recording
2. Two clock-face tests (CFT-2) for practice. This consists of two series of front positions and two series of back positions
3. Further discussion if trainee was interested
4. Final tests in localization: speaker and earphone presentations

GROUP B -- All steps for Group B were exactly the same as for Group A with the following exceptions:

Session I

5. The first speaker training recording (SPTR 1) This recording and the others for use over the speaker-system were the same as the CFTR-1, etc., except that the sounds monaurally recorded were switched through the appropriate speakers surrounding the subject as he sat in the center of the soundroom.
6. A speaker test of localization (SPT-1) (Similar to CFT-1)

Session II

1. The second speaker training recording (SPTR-2)(Similar to CFTR-2)
2. Two speaker tests (SPT-2) for practice (Similar to CFT-2)

Testing Localization

Each pretest and each final test consisted of 14 localization trials. In both the binaural earphone test and the speaker test the narrator's voice asking "Where am I?" and a low frequency rattle came from the clock-face positions in random order. There was a pause of 8 seconds for the subject to answer each time. He was required to point toward the clock position where the narrator seemed to be and to say the clock position. For the first seven of the fourteen clock position trials the narrator spoke from the clock positions in the front half-circle. For the last seven trials the narrator spoke from the seven clock positions toward the back. The 9 o'clock and 3 o'clock positions appeared in each half of the test. Before each half of the test it was emphasized to each subject whether the sounds would come from the front half-circle or from the back half-circle.

Each of the four tests was scored by two methods. Measure 1 was obtained by averaging the clock hour errors. If the correct answer was 4 o'clock and the trainee answered 5 o'clock, this counted as one clock hour of error. For each test the mean clock-hour error was calculated for individuals

and then averaged for the group. Measure 2 was obtained by simply counting the number of exactly correct locations which were made by each individual. The differences were found between pretest and final test performance on binaural recording-earphone and pretest and final test performance on speakers using both Measure 1 and Measure 2. These indicate the improvement scores.

Statistical analysis consisted of t tests to make meaningful comparisons between the various means.

c. Results

Tables in Appendices 9, 10, 11, and 12 give results and statistical analyses. Appendix 9 reports the mean localization scores in terms of Measure 1, Average Clock-hour Error. Appendix 10 reports them in terms of Measure 2, Number Correct. The third column in each of these two tables indicates the improvement score or mean difference between pretests and final tests.

The most obvious result is that the mean for every speaker test consistently represents a better localization score than the corresponding mean for the earphone test. For scores in terms of error (Measure 1, Appendix 9) the better score is a lower figure; for scores in terms of number correct (Measure 2, Appendix 10) the better score is, of course, a higher figure.

The table for Measure 1 (Appendix 9) shows that there was a significant improvement in localization scores for both groups (earphone trained Group A; and speaker trained Group B.) and in both types of tests (earphone; speaker). Each improvement was significant at the 1% level of confidence.

The table for Measure 2 (Appendix 10) shows a significant improvement in scores for each group when tested with the same method by which it was trained.

Appendix 11 restates the mean localization scores. This analysis, however, is a comparison of the means of the two groups on their corresponding tests. At no time (pretest or final test), with neither type of test (earphone or speaker) and with neither measure (error or number correct) was there a statistically significant difference between the two groups. When they began testing there was no significant difference; when they took their final tests there was no significant difference between the two groups.

Appendix 12 shows the frequency of front-back errors which occurred on the pretest and final test by means of the earphones. In the pretests a total of 49 reversals occurred; in the final tests only 8 occurred. Each subject was given 14 trials for each test but 4 of these were directly to the side (9:00 and 3:00 positions) so his chances for front-back error on each test were 10. For all 23 subjects the chances for such error were 10 x 23 or 230 for the pretest and 230 for the final test.

d. Discussion and Conclusions

From the consistently better localization scores on the part of subjects in group A and group B when locating sounds remote from the individual (i.e. from speakers) one concludes that better localizing cues are present than those on the recordings for earphones. In this instance subjects were allowed free head movement while locating sounds from the speakers. This is the most obvious localization cue which distinguishes localization of earphone-

presented sounds and localization of speaker-presented sounds. To determine whether or not this is the only different cue would have required a comparison of the two groups with a third group of subjects locating speaker sounds while their heads were held stationary.

Results are slightly different when interpreted by means of two different measures of success. The following should be noted carefully in interpreting the results: Measure 1 is more sensitive than Measure 2 since it does more than indicate how many trials were correct; it also indicates degree of error (or inversely, of "correctness").

The most important conclusion is generally a positive one concerning the effects of localization training by means of binaural recordings. The analysis of Measure 1 shows in every case significant improvement, although results by Measure 2 are less clearly positive. That is, Measure 2 would indicate that the speaker-trained group improved only in speaker tests and the earphone-trained group improved only on the earphone-test. Yet this is true only when localization scores are expressed by means of this particular measure. Nevertheless, improvement in the speaker-test (representing a real situation in which one is ultimately interested) showed up for the earphone-trained group at a degree which approaches statistical significance (10% level).

The lack of significant improvement (Measure 2) in the earphone test of the speaker-trained group is no surprise. The final earphone test was only their second experience with the use of earphones for localization purposes and Measure 2 is less sensitive.

Results indicate the care that is necessary in choice of scoring methods, or measurement. Generally, however, this experiment has answered positively the question: Will training with binaural recordings result in better localization of "real" sounds, i.e., sounds which emanate from sources remote from individuals? There is validity in this training. The *t*-tests reported in Appendix 11 indicate the lack of difference between the two groups on any one test. Pretest results indicate that our two groups were comparable to begin with and that comparisons of experimental results are, therefore, meaningful. That there is little difference on final tests indicates that both training methods in localization were effective.

It is important to note the practical implications of these results. Binaural recordings can be used without the expenses involved in constructing an acoustically treated soundroom with a speaker system. Clients using the recordings do not need constant attendance of instruction personnel; whereas, an operator -instructor is required for the speaker system unless expensive automation is involved. Furthermore, groups of clients can be given instruction at the same time using the recordings, an impossibility with the multiple speaker system.

The one problem of the earphones and binaural recordings -- front-back confusion -- seems to be less of a training problem in light of Experiment C. Appendix 12 shows the frequency of front-back errors on (1) pretests and (2) final tests. There were so few errors of this type on the final tests that we can conclude positively concerning the present method of dealing with this problem. Subjects were told (1) whether they would hear front (180°) sounds or back (180°) sounds and (2) that they must "really imagine" the situation. Subjects were also instructed to close their eyes and not to turn their heads while listening. When they were then given simple instructions on head turning in real life situations, the lessons were almost immediately applicable.

5. Comparison of Performance for Recorded and "Natural"Traffic Sounds: A Validation (1960)

a. Introduction:

A primary goal in hearing training is to present to trainees pertinent traffic sounds which, on record, they will be able to interpret. This experiment was designed to compare the performance of a totally blind very experienced (30 years) traveler as she listened to traffic by means of the binaural recordings and as she listened to similar traffic sounds on a street corner. If the recordings were useful, her two performances should not be significantly different. In other words, the recordings and present recording methods would then be considered of reasonably high quality and valid for training purposes.

b. Method

The task for the Subject in each case (on record and on the street corner) was to state when it was safe to cross the street directly ahead of her after each signal, "Start listening."

For the experiment a city street corner was chosen where traffic is relatively heavy and where no vehicle can make a turn in either direction. A day was chosen for testing and recording when the wind was low.

The traffic light cycle was carefully timed for the series of trials. The signal to start listening occurred at random intervals during the 32 seconds of green light for traffic on the street directly ahead; that is, the Subject was told to start listening during the time it was not safe to cross the street.

For each trial the Subject was positioned with toes at the curb in time for the Experimenter to say "Start Listening." Between trials the Subject, Experimenter, and Assistant turned away from the curb and chatted informally. No instructions were given on the street corner concerning head turning; the Subject was free to use her usual method.

She was instructed to say "Now" when she knew it was safe to corss. The time in seconds was measured with a stop watch from the beginning of caution light (which could stop traffic directly ahead) to her response "Now." The trial was counted as correct if there were time to reach the opposite curb before the green light allowed traffic to go. (Premeasurement indicated a "safe" interval of 18 seconds.)

Several series of trials on the street corner were given, sometimes with the side street to the left and at other times with the side street to the right. In the comparisons with recorded sounds, only the trials with the side street to the left were used because this was the way in which the recorded traffic sounds were made.

For the recording, the artificial head was placed in approximately the same position as the Subject's head when she stood on the corner. The signal on the recording for "Start Listening" for each trial was a sharp click. By knowledge of the pre-arranged timing the Experimenter was able to time responses accurately as both Subject and Experimenter listened to the series of traffic sounds on the recording.

While listening to the recordings, the Subject was, of course, instructed not to turn her head and to "really imagine the situation." Her task was exactly the same as on the street corner. The subject was a novice to earphone listening.

c. Results

The Subject was confused for the first 20 minutes of testing by recording. She kept saying "I can't do it." Suddenly her performance began to be entirely "correct." It is assumed that the time was needed for orientation to the earphones and recordings; so for comparison scores the last 12 successful trials are compared with 14 "natural" trials which are comparable in that they were made with the side street to the left.

The mean time for the Subject's "natural" performance is 9.1 seconds; the mean time for performance to recorded sound is 10.6 seconds. The _t_-test shows that the difference between the two means is not statistically significant. ($t = .9202$; $df = 24$)

d. Conclusions

The result of "no significant difference" speaks well for the quality of the binaural recordings of traffic sounds. This is another small piece of evidence of the "realistic" quality of the recordings, and is another practical validation of the method.

The confusion of the Subject at the beginning of listening to the recordings does indicate, however, that experience in listening to the binaural recordings is necessary in order for an individual to make "heads or tails" of them.

6. Trainee Evaluation of Hearing Training (1959;1960)*

A group of twenty trainees early in the project (1959) were asked to give their opinions of the hearing training they received. The study served as a pretest of questions for the later,more controlled evaluation questionnaire

For the later study, twenty-two of the twenty-four clients who served as experimental subjects in Experiment C were contacted by phone for follow-up evaluation. These clients were totally blind and only two were able to travel independently. They were asked a series of questions as follows: (Numbers in parentheses indicate respondents giving that answer)

1. Do you think that recordings of sounds and talking about the use of hearing would help blind persons generally? yes__(20); no_(0)__; I don't know__(1)_; Maybe__(1)_;

2. Besides binaural recordings of sound localization the plan is to make recordings of sounds at home -- in the kitchen, for example -- sounds in a residential neighborhood street, and sounds of traffic. What sounds at home seem important? What sounds might we include on a residential street? What kinds of traffic sounds should be pointed out? Would you add anything else?

3. Do you think hearing training would be useful too: all blind persons_(14); most blind persons_(6)_; about half the population of blind persons_(1)_; a few blind persons_(1)_; no blind persons_(0)_;

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*Miss Muriel Kronick, Research Assistant for most of these experiments was primarily responsible for this study.

4. Do you think hearing training would be more useful to the totally blind (19); partially sighted (1); both (2) ; Do you think the partially sighted would benefit to some extent? yes 20 ; no 0 ; questionable 2 ;

None refused to answer. All seemed very cooperative and eager to answer the questions, express their opinions, and offer their own comments regarding hearing training.

The concensus was that recordings of sounds and talking about the use of hearing would help blind people generally. Only one client of relatively low intelligence stated she didn't know if it would in that she "didn't understand the test or its purpose".

The majority of clients agreed that hearing training would help all blind persons. Twenty clients stated that hearing training would be more useful to totally blind persons than to partially sighted persons. Many expressed the theory that a partially sighted person will tend to rely on his vision, no matter how limited, rather than rely on his hearing. A partially sighted person "does not want to be blind." This would seem to be a problem of an individual nature rather than a general one and would depend on an individual's adjustment to his handicap.

A list of important sounds was compiled. Most people found it difficult to name these sounds because they are sounds that are "taken for granted." Clients living in housing projects, where conditions are usually crowded and people live very close to each other, stated that "it is hard to discern many sounds because the projects are so noisy."

Several clients stated that they profited a great deal from the hearing training they received and are now more aware of sounds and their location. They seem to have become aware of how they had previously used hearing without "thinking about it;" they seem to have become aware of more possible ways to use hearing.

"Important sounds" mentioned more than twice are as follows:

Home: doorbell (6); telephone (2); radio (4); gas (2); footsteps (3); boiling (6); frying (4); clocks (4); television (3); leaky faucets (2); tea kettle (2);

Traffic: trucks (2); cars (13); horns tooting (3);

Street: people walking (9); children (9); dogs (3); bicycles (4);

The following are interesting verbatim statements:

"Head turning has helped me." "You can hear people breathing." "It is devilish quiet in the wintertime. Winter is a problem period for lack of sound." "Anyone can improve his observation of what he hears." "Decipher what the other person is doing and where he is -- know if someone is reading, smoking, sitting. Cross-examination is not conducive to good relationships."

Repeated ideas are illustrated by the following verbatim statements:

"Totally blind people pay more attention to hearing." "Hearing training calls your attention to sounds -- you notice more." "Partials will be trying to see." "It all depends on how much they (partials) depend on their sight. They don't want to be blind; therefore, they won't train their ears. Totals listen because they have to listen."

The earlier study upheld the experimenters' pre-judgment that most considered the following important for good orientation: (1) a "map in the head," (2) sounds as reference points in that map. Most of the early group mentioned the following as useful to be included in hearing training: (1) how two ears operate in hearing (2) the use of head-turning as a cue to localization (3) the use of sound reflections, i.e., echolocation techniques and (4) methods for continued development of listening techniques after training sessions. All of these ideas are included in present methods as suggested in the manual.

7. Head Movements in Relation to Location of Sound Sources (1960)

a. Introduction

A series of motion pictures was made of four clients while they attempted to locate sounds. The purpose was to gain preliminary insight into the relationship of head movements and the location of known sound sources. The movements on film could be examined many times. The method itself, of making the films for measuring head movement, was to be analyzed.

b. Method

Motion pictures were taken by a professional photographer of four trainees (of Experiment C) who were being trained in localizing speech (Where am I?") and a low frequency rattle, by means of the 12-speaker-system of the sound room.

The series of motion pictures was made of the trainee locating 30 selected positions throughout the 5 tests. Clock positions to be located on each test were in random order.

The camera was focused through a black grid, (one inch square heavy wire) at the control room window. A circle of contrasting adhesive which photographed the width of a square of the grid was attached to the center of the subject's forehead in order to trace movement on the grid. The trainee was told that the instructor needed to use the adhesive tape to be sure the subject was centered in the room before testing began. None of the subjects knew the pictures were being taken. Included in the motion pictures were the switches which determined to which speaker the sound was going at a given time.

It was planned that the following type of data be collected: (1) Subject's position before speaker is turned on for each localization trial; (2) Movement when speaker is turned on (small or large; in what direction, etc.) (3) Movement when voice is heard over speaker. (4) Movement after Subject's verbal response. (5) Did arm movement in pointing to the sound seem to cause the body or head movement? (6) If response was incorrect, what response was given? How much error was there in terms of clock hours? (7) For "front" sounds does Subject face sound source? If not, what movement is made? (8) For "back" sounds does Subject locate by turning one ear directly toward the source? If not, what movement is made?

The Experimenter and the Research Assistant viewed the films several times in order to formulate a few tentative hypotheses and to formulate research questions concerning head movements and localization of sound sources.

c. Results and Discussion

Motion pictures as made in this study for registering or measuring head movement were found to be limited in usefulness. Movements are measurable only in gross terms. Movies can be made to register minute movement, but one big complication is that heads move in many directions, turn on an axis, etc. Our measurement was far from precise. Besides motion pictures, a possibility is the use of EMG techniques, electrical measurements of extremely small muscle movements, as well as other electronic devices.

However, several patterns did appear which may or may not hold true generally, especially since there were only four subjects studied.

Almost always in a free head turning situation a person turns his head toward the side on which the sound occurred. Earlier observations had suggested that in real-life localization of sounds from the front (not quite 180°) was accomplished by facing the sound source and that localization of sounds from the back (probably excluding the 6 o'clock position directly behind) was accomplished by pointing the nearer ear toward the sound. For the two persons who have been blind several years (but do not travel alone) this seemed to be precisely what happened. Their head movements were also quite free and large, and occurred before they attempted to respond concerning locations. The two subjects more recently blinded were stiff and made small or no head movements at first. For them, somewhat larger head movements occurred as they attempted more and more localization trials. It must be remembered that during the course of training it was taught that head-turning provided good cues to localizations of sound sources. The more experienced seemed to use the head-turning as a scanning device in the auditory world.

The two more experienced blind persons made much better localization scores than the two more recently blinded. Head movement, *per se*, is probably a key factor. Perhaps also the methods of facing a sound source and pointing an ear toward it are functional factors.

From present data it is not possible to compare how well subjects localize front and back sounds. In present tests the front series is always first. For adequate experimental control and for any valid conclusions concerning differences of front and back localizations, the order would have to be systematically varied. Present data does *suggest* that front localizations are more easily accomplished. If that is so, it may be analogous to the use of the visual field. More that is experienced is in the lower half of the visual field; perhaps more that is experienced (or noticed) in sound is in front of a person.

In further experimentations on localization, however, it will be necessary to separate variables of "frontness/backness"; locating by facing a sound source/locating by pointing an ear toward a sound source. One could then answer the questions: Are front sounds really easier to locate than back ones in a free head turning situation? If so, is it due to method of location which is physiologically limited in that the head cannot rotate fully? Facing the sound source means the subject is "tuning in" by somewhat equalizing the two ears' signals. Pointing an ear toward a sound means he finds large differences between the ears. It might then be the *method* of location, limited by physiology of possible head movements, not frontness or backness *per se*, which causes any difference between localization of sounds to the front as compared to localization of sounds to the back.

Two observations are especially important: (1) differences between experienced and newly-blinded individuals in head movements and (2) the development with practice of more frequent, larger movements by the newly-blinded. These call attention to the need to analyze more carefully and to identify the movements which occur with good localization and orientation. Simple practice in localization and instruction about head-turning may be sufficient for improvement, but perhaps other training methods are possible.

This study emphasizes the importance of head-turning (as well as congruent proprioceptive stimuli) as a factor in "good" listening and orientation in the auditory world. This means that while the use of earphones and present binaural recordings is valuable in hearing training it alone will lack a vital factor for localization -- the possibility of head movement to obtain more than one "point of view" in sound. It also suggests further research should be conducted in "speaker rooms" such as described in Section II-A.

C. Clinical Experience

Many observations were made clinically which have not been examined by statistical methods or perfectly objective measures. In the last year and one-half of the project approximately 90 blind persons have received hearing training in one of several forms. Besides acting as subjects for various experiments, they have provided opportunities for clinical observations. A main result was development of the procedure for hearing training; for example, the exact wording of information on hearing and directions for using the earphones were worked out with experience. There are other ideas which should be reported as well.

The experimenter was interested in observing the reactions of trainees to hearing training. Interest seemed to be high. A positive attitude was evidenced by full cooperation, by readiness to discuss hearing experiences, and, of course, by the responses to evaluation questions. Several suggestions from trainees, usually the more intelligent ones, were incorporated in final recordings and in the manual.

The idea that we <u>learn</u> to use earphones and binaural recordings grew out of our first attempts to train persons. It seems that in using binaural recordings we learn to "fill in the blanks" or interpret what is not quite a replica of reality. One client reported, "I soon learned that when the sound seemed on top of my head, it was coming from directly in front of me." When a person first listens to the binaural recordings, he can be compared to members of certain primitive peoples who cannot interpret simple photographs or snapshots which represent, but do not duplicate, the real visual world.

The idea arose from first clinical observations that a person might learn to imagine more easily a situation to the front or the back simply if he were told where the sound sources would be; more elaborate methods were unnecessary. As reported in Experiment C this technique is largely successful in overcoming the front-back problem of binaural recordings.

<u>Passive Listening</u>: The training methods were based from the beginning upon a principle called "passive listening" which gained clinical support. "Passive listening" means simply that the trainee is not actively engaged in travel. In this sense only is he passive. He is active in paying attention to the auditory world; he is responding and testing it out verbally. This means, too, that he can isolate hearing for his focus of attention. "Passive

listening" refers not only to listening to recordings but also to real situations where, for example, a trainee uses a sighted guide.

Several trainees made remarks of the following general nature: "I'm getting better (in hearing); maybe I could go out alone." "I tried to learn how to travel, but I had to learn to do too many things at once; maybe now..." "I took travel training, but he didn't tell me much about using my ears."

Success and Failure: Training was also based on the idea that a person learns fastest when he experiences both success and failure. According to learning experiments, animal and human subjects learn best when rewarded for correct responses and punished for incorrect ones; they learn next best when only rewarded for their correct responses, and they learn least well when only punished for incorrect responses. Experiencing success and failure is similar to reward and punishment. Experience with our trainees simply bears out this basic principle of learning. Training is a series of controlled successes with inevitable failures, too.

Trainees also like to verify their responses, that is, to know how well they are doing: "I really am doing better." "I'm glad you always say what the correct answers are. Then I know if I'm right." "I don't mind being wrong, if I can just know."

Fear: The two basic techniques (1) of experiencing (and verifying) success and (2) of passive listening probably help overcome fear of travel and give a trainee confidence. Fear can preclude perception of "reality." Attention cannot "focus." So to foster good listening one can at first take away the fearful part of orientation (by "passive listening") and provide hearing experiences with controlled successes and failures. Remarks by clients are as follows: "It's like learning to swim -- learn one part of the thing at a time, then put them together. Listening is one part of getting around OK." "If you listened enough like this, you could learn to trust your ears."

That fear is actually decreased for later travel must still be determined. For the present we have some reason to believe that when a blind person learns he can trust his ears, he will be more able to manage his fear.

Experienced Blind Travelers: Two totally blind expert travelers who were by accident included in Experiment C provided us with the clue that such persons are already excellent in localization ability. Their pretest scores on the speaker test of localization were almost perfect (although their earphone tests were average.) Their scores on the final test were perfect. They were also able without instruction to put into words the different ways of orienting by sounds. This seems to indicate that teaching the information on how to orient by sounds, and training in localization are valid goals.

Other Factors: The data so far give no pattern to the relationship between orientation ability (as measured by simple sound localization) and such factors as age or intelligence. It is an impression that the younger trainees (of the adults 18 and up) benefited more from the training. The impression could of course, be due to the greater energy-activity level of younger persons.

Learning speed seems to be related to intelligence, but many persons of low average intelligence improved to a high level of competence in localization. The patterns and various factors involved need clarification.

Clinical observation corroborates the opinions of trainees in the Evaluation studies. The partially sighted trainees seemed interested, but most remarked spontaneously that "this would be more useful to people who can't see at all."

D. The Manual for Basic Hearing Training

The manual, Training Hearing to Greater Usefulness, by Fay-Tyler M. Norton, is available primarily for orientation instructors and researchers. It is 35 pages long, written in non-technical language. It contains summaries of the necessary equipment, of recording techniques, and of the research. It contains detailed notes on training clients in the use of the earphones and binaural recordings. It contains complete scripts of the ten recordings now available and is published in loose-leaf form for additions already planned.

A last section contains twelve suggested "Exercises in Listening" designed to supplement listening to the recordings. These make full use of safe, passive listening techniques in a variety of situations. They provide the opportunity not afforded in earphone listening to practice the important congruent head movements in listening for better orientation. References are made to non-technical books for the orientation instructor and intelligent trainee to further their understanding of binaural hearing, "stereo," echo-location, etc.

Copies are available to professional persons upon request to the Cleveland Society for the Blind.

E. General Conclusions:

Granted that hearing and careful listening are of great importance in orientation of blind persons, the recordings and training program described in the manual will provide basic training in a relatively short time, with relatively little effort on the part of an instructor. The following questions have been answered satisfactorily: Will localization and identification of "real" sounds improve with the use of binaural recordings? Yes. Do present methods raise interest? Definitely. Can the front-back ambiguity of the recordings be overcome? Yes. Can average people learn to use the earphones? Certainly. Are the recordings realistic enough with present techniques? Yes, though there are certain limitations.

Recordings must be added to the present set -- primarily recordings of the outdoors and traffic. The Cleveland Society has made traffic recordings adequate and realistic for experimental purposes but probably inadequate for training. It has been our experience that these -- and other "you-are-there" recordings -- must, for training, be made with the same professional care as educational radio shows. To produce such recordings requires a staff of (1) expert technicians -- engineers, etc. (2) a production staff -- director, sound crew, etc., (3) professional actors or narrators, where such are called for, (4) a writer, and (5) consultants in work with the blind and in education.

The real problem however is improvement of mobility and orientation in "real" life. Is recorded experience sufficient for even indoor orientation? At present one must say it may never be sufficient by itself. In earphone listening head movements are precluded; and head movements are a major cue to sound localization. "Natural" listening is, whether we like it or not, different from earphone listening. In real life a person makes full use of many types of stimuli, especially of all concommitant proprioceptive stimuli. Listening for orientation involves association of other factors with auditory cues. For example, in learning to drive a car, some training can be accomplished by motion pictures of what is seen through a windshield and steering wheel manipulation, but one doesn't get the "seat of the pants" feel of the car. The total, real situation is still different from the simulated one.

This is a limitation of the use of recorded sound experiences. The other main limitation in the use of binaural recordings is the fact that the necessary equipment is expensive and must be carefully cared for by trained personnel in order for sounds to be properly reproduced. A further limitation lies in the fact that an instructor must still give personal attention to each trainee to motivate him and to adapt training to his individual needs.

For every disadvantage or limitation, however, there are advantages. It is highly probable that present techniques will considerably shorten the training period in "real" travel, as well as in simple localization or orientation to sounds. A wide range of auditory experience can be immediately available on recordings. Time and energy of both instructor and trainee are saved. With little effort group instruction and discussion can be developed for further time and energy savings.

A primary accomplishment, of course, is development of trainee enthusiasm, not just for better listening, but also for the use of all available perceptive powers to solve the problem of orientation.

<u>Use of the project results</u>: The recordings and training program described in the manual can presently be used in major agencies serving blind persons which have (1) personnel to train clients in orientation, (2) sufficient numbers of clients, and (3) sufficient funds (approximately $1,500.00 to start). The manual without recordings can also be useful to an ingenious instructor who can use the ideas it contains.

All the material, it is hoped, will also provide enough controversial matter to spark any researcher concerned with orientation and mobility of blind persons. With those who differ with the suggested ideas and hypotheses lies responsibility of proof.

III RECOMMENDATIONS FOR FURTHER RESEARCH

The need for several minor research projects has already been reported in connection with the findings which provoked them. There are, however, a few problems which assume major proportions at present.

1. The most obvious need is a major effort to determine validity of present hearing training in connection with travel training. The design is simple enough. Two comparable groups of newly blinded, totally blind individuals receive travel training as given by recognized methods. One group also receives hearing training. Results of the two groups can be compared as follows: (1) relative progress in orientation and travel ability, (2) final ability, and (3) ability after many months. It is obvious that valid results will be obtained only if strictest experimental controls are employed.

2. The need for a major validity study brings the researcher immediately to the major problem of measurement of orientation and/or travel ability. With present interest in mobility, measurement that is both reliable and valid is a must. Present "rubber yardsticks" and subjective judgments will not be adequate.

Any kind of evaluation of mobility, including a mobility achievement course, brings up the problem of criteria of what constitutes "good" or "bad" traveling. Someone has to answer the question: "What observable behaviors (or abilities, or even personality characteristics expressed preferably in operational terms) indicate and constitute "good mobility?" Examples of criteria are such things as "not bumping into obstacles," "walking a straight

course keeping sounds of traffic to one side," "orienting oneself squarely with a street while waiting to corss," or, a general criterion, "arriving safely at a destination."

A usual approach to deciding on criteria for any achievement is to take the combined opinions of experts in the field. All measuring instruments from such places as the Industrial Home for the Blind, Perkins Institute, St. Paul's Rehabilitation Center, the Veteran's Administration, Shilling Laboratories, etc., should be studied. The agreed upon important factors could be incorporated into measuring devices.

Several other problems enter here: (1) to define mobility/orientation ability, perhaps differentiating persons well oriented outdoors/indoors and (2) to deal with the problem that there seem to be two kinds of "good" travelers -- (a) those who follow straight courses, don't bump into things, are always oriented, and of course, arrive at their destination and (b) those who go everywhere by themselves but who do so in a "bumbling" fashion.

Several types of measurements and evaluations should be made and systematically compared, for example:

(a) evaluations by instructors -- usually in the form of rating sheets
(b) responses (in interview) by blind persons to questions concerning their mobility behavior
(c) field tests (in controlled indoor and outdoor areas)
(d) performance on mobility achievement course(s)

The aim of a mobility achievement course or other measures of mobility can be one of two: (1) a standardized test of mobility with the score of an individual having meaning in relation to norms or (2) a mobility test with at least face validity and high reliability, and with the scores being meaningful where experimental and statistical controls are exercised, e.g., when experimental group means are compared with control group means. Number (1), the standardized test, may be an ultimate goal, but for experimental purposes (and as a beginning Number (2) can be more readily achieved.

Without good measurement and definition of the ability studied, research will lack precision and will not reveal clear-cut answers.

3. A third great need is simple precision in experimental designs -- whether the subject for research be mobility, audition, or anything else. Often lacking is a clear statement (1) designating the research variables (and their method of measurement) and (2) identifying controls employed (both experimental and statistical).

4. General survey methods should be employed to determine the needs of blind persons or newly blinded persons for orientation and mobility training.

5. A list of research needs falls short if it does not include research for better instrumentation. This set of variables needs the work of the best technicians just as do the psychological variables. The two approaches to hearing training must reinforce the other. But perhaps it is even more important to study the inter-relationships among the two classes or types of variables, i.e., psychological and instrumentation factors.

The following is an example of the instrumentation-psychological problem: Life Magazine, September 19, 1960, reported on findings of Dr. Robert Hanson of the Bell Telephone Laboratories. The report stated that the effect of depth was better when he listened over matched microphones at the ears of a

"head" attached to the top of his own head than when the "head" was immobile on a table. On the basis of this report, a letter posing some important questions was addressed to Dr. Hanson.

> Does the better depth perception occur also (1) when the artificial head is attached to someone else's head or (2) when a recording has been made from atop your head and you listen to it later? I am questioning in regard to the factor of congruence of your own and the artificial head's movements. Another factor would be your total environment -- other sensory data confirming hearing data when you are in the situation and not confirming the hearing data when you are listening to recordings or to sound picked up from atop another person's head.
>
> I believe my practical question is this: Will the minute movements of just anyone's head make recordings for other people that add significantly to their binaural auditory perception? Have you data which concerns localization and the "head's" movements as well as depth perception?

Dr. Hanson's reply did not address itself to any of these critical questions and we must assume that the research needed to answer them has not been done. An inter-disciplinary team attacking such instrumentation-psychological problems is definitely important in the future of research on problems of the blind.

6. Research recommendations would be lacking also if we failed to mention the need to study the personality variables of "good" and "bad" travelers.

IV PUBLICATIONS; PUBLIC AND COMMUNITY RELATIONS

December, 1959, and June, 1960 -- Two articles in The New Outlook for the Blind by Fay-Tyler Norton, principal investigator for the project. (See Bibliography, Section V, B.)

March 3, 1960 -- An address "Research in Hearing Training - The Binaural Approach" by Dr. Norton to the annual conference of the Greater New York Council of Agencies for the Blind.

1960 -- "Training Hearing to Greater Usefulness", a 35-page manual published under this grant written by the principal investigator.

March 12, 1960 -- A 15-minute broadcast of an interview of Mr. James Hyka, Supervisor of Employee Services at the Cleveland Society for the Blind (formerly Director of Rehabilitation), and Dr. Norton, concerning the "hearing project". It was sponsored by Cleveland's United Appeal and presented by radio station WGAR as a public service.

Spring, 1960 -- The evening news show of KYW-TV told of the hearing project in connection with the completion of the acoustically-treated room contributed in part by a local Lions Club.

Spring, 1960 --"Grotesque Head Records Traffic Sounds for Blind" was the headline for a Cleveland Press news article accompanied by a picture of the recording "head" when traffic sounds on a busy intersection were being recorded.

The above serve to illustrate the public information and communications aspect of the project. Other articles also appeared in local newspapers from time to time. The monthly NEWSLETTER of the Cleveland Society for the Blind carried progress reports of the research to its readers. Classes from the universities visited the agency to learn of its research and left with a better concept of the functioning of the agency as a whole. The Cleveland Police Department expedited the tedious job of recording on one of Cleveland's busy street corners.

The staff and board members of the Agency were brought into closer contact with research and research needs. Staff began to think in terms of research and to develop their own research projects.

Community resources in research were marshalled for the agency. Research specialists at the university and in private research agencies contributed many hours of free consulting services.

The project helped bring about closer state and national ties. Research is now being carried out in cooperation with the Ohio Division of Services to the Blind. The best thinking of specialists from the American Foundation for the Blind and the Office of Vocational Rehabilitation was available not only in regard to this project, but also in regard to other problems of the agency.

In the spring of 1960 better understanding was achieved by a conference of the research staff of three major agencies conducting research on hearing and orientation under grants from the Office of Vocational Rehabilitation, U.S. Department of Health, Education, and Welfare.

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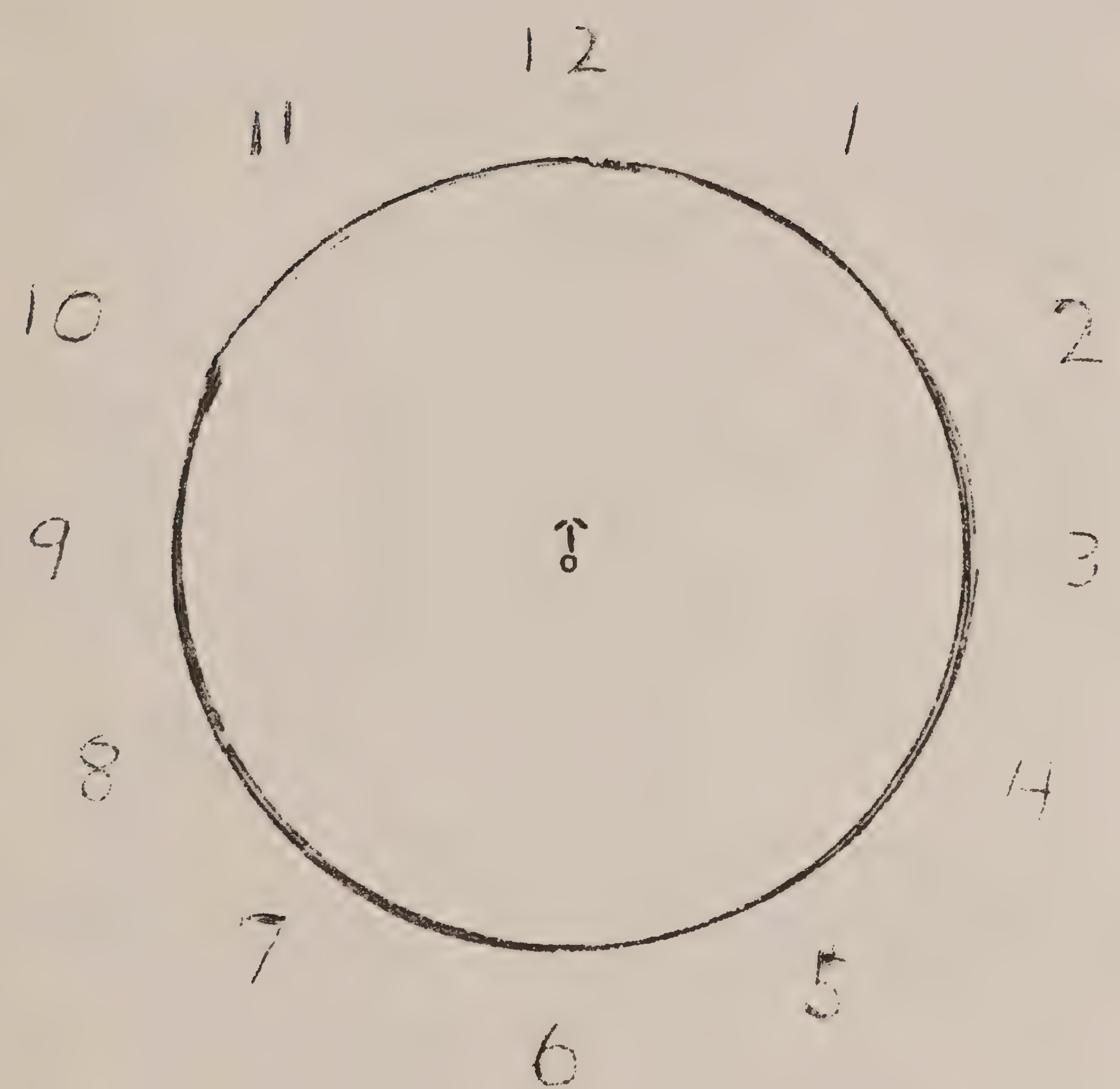
APPENDIX 1

THE CLOCK-FACE



The clock positions represent the locations of sound sources -- the speakers in the sound room, as well as the positions from which the Narrator spoke to "Mike," the artificial head containing the microphones at the ears.

AROUND THE CLOCK-FACE: II

RECORDING #6

(Narrator at 12 o'clock)

Narrator: This is the second recording Around the Clock-Face. It will help you improve your ability to locate sounds. Again use the large clock-face to tell where I am. When I am directly in front of you as I am now you will say I am at 12 o'clock.

Listen as I go around you counter-clock-wise. Point toward me at each clock position.

(N at 11 o'clock)	This is 11 o'clock	(N makes sound)
(N at 10 o'clock)	This is 10 o'clock	(N makes sound)
(N at 9 o'clock)	I am now at 9 o'clock	(N makes sound)
(N at 8 o'clock)	Now I am at 8 o'clock	(N makes sound)
(N at 7 o'clock)	This is 7 o'clock	(N makes sound)

Are you pointing to me at each position?

(N at 6 o'clock)	This is 6 o'clock	(N makes sound)
(N at 5 o'clock)	Now I am at 5 o'clock	(N makes sound)
(N at 4 o'clock)	I am at 4 o'clock now	(N makes sound)
(N at 3 o'clock)	This is 3 o'clock	(N makes sound)
(N at 2 o'clock)	Now I am at 2 o'clock	(N makes sound)
(N at 1 o'clock)	I am at 1 o'clock now	(N makes sound)
(N at 12 o'clock)	And now I am back at 12 o'clock	(N makes sound)

Let's listen to the difference between sounds coming from the left and sounds coming from the right.

(N at 11 o'clock)	11 o'clock is to the left front	(N makes sound)
(N at 1 o'clock)	1 o'clock is to the right front	(N makes sound)
(N at 10 o'clock)	10 o'clock is to the left front	(N makes sound)
(N at 2 o'clock)	2 o'clock is to the right front	(N makes sound)

Now let's try positions toward the back of you.

(N at 7 o'clock)	This is 7 o'clock	(N makes sound)
(N at 4 o'clock)	This is 4 o'clock	(N makes sound)
(N at 8 o'clock)	This is 8 o'clock	(N makes sound)
(N at 5 o'clock)	This is 5 o'clock	(N makes sound)

Now we will see the difference between clock positions that are next to each other.

(N at 1 o'clock)	This is 1 o'clock	(N makes sound)
(N at 2 o'clock)	This is 2 o'clock	(N makes sound)

Can you tell the difference now?

SELF TEST:	(N at 2 o'clock)	Where am I?	(N makes sound)
	(N at 1 o'clock)	Where am I now?	(N makes sound)

Did you find me? First I was at 2 o'clock and then at 1 o'clock.

(N at 4 o'clock)	This is 4 o'clock	(N makes sound)
(N at 5 o'clock)	This is 5 o'clock	(N makes sound)

SELF TEST: (N at 4 o'clock) Where am I? (N makes sound)
(N at 5 o'clock) Where am I? (N makes sound)

If you were correct you said 4 o'clock first and then 5 o'clock.

(N at 7 o'clock)	This is 7 o'clock	(N makes sound)
(N at 8 o'clock)	This is 8 o'clock	(N makes sound)

SELF TEST: (N at 8 o'clock) Where am I? (N makes sound)
(N at 7 o'clock) Where am I? (N makes sound)

If you were correct you said 8 o'clock and then 7 o'clock.

(N at 10 o'clock)	This is 10 o'clock	(N makes sound)
(N at 11 o'clock)	This is 11 o'clock	(N makes sound)

Now you try to find me.

SELF TEST: (N at 11 o'clock) Where am I? (N makes sound)
(N at 10 o'clock) Where am I now? (N makes sound)

First I was at 11 o'clock and then 10 o'clock.

(N at 12 o'clock) Let me illustrate now the way you judge distance. In order to judge distance of things by means of sounds, you generally have to be familiar with the sounds. Then, of course, loudness is one of the more important cues to distance, and so is the quality of the sound.

(N moves forward and back on next line) Listen to my voice as I now come closer to you and then back away into position. (N moves forward, turns around to walk away on next line)

Now listen as I come closer and turn around to walk away from you. (N at 12 o'clock) Now I am facing you again.

Let's try the same thing at 10 o'clock. (N at 10 o'clock moves forward and back on next line.) I am moving forward toward you and now I am backing away from you. (N moves forward and turns around to walk away on next line.) Listen as I come forward and then turn around to walk away from you and again face you at 10 o'clock.

That was just an illustration of what you do every day to judge distance by means of sound.

(N at 12 o'clock) Let me talk now from the 12 o'clock position. There are three ways to detect objects by means of sounds. We have been using only one. You have been locating objects, the rattle and me, by listening to the sounds <u>we</u> make.

A second way is to locate a <u>silent</u> object which moves in a sound field. For example, suppose another person were here. If that person moves in front of me, my voice would sound different. (Other person moves by N slowly) Then you could locate that person even if you could not hear his footsteps. Did you notice the difference?

As I continue talking listen for the difference when a person steps in front of me and back again. I will count -- and you listen for the difference in voice as the person blocks the sound of it. The difference may be very small.

(action on 4 and 8) 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Did you detect the difference?

A third way to locate objects by means of sounds is to make use of sound reflections. Most of what we hear every day is reflected sound. You hear not only my voice from my mouth but its reflections from every surface around us. These sound reflections -- from a wall, for example -- tell you the location of things.

I won't try to illustrate that now, but I will tell you about it. Perhaps you have heard that the experienced blind person can tell when he passes an open door. For example, when we walk down a hallway many sounds including our footsteps and voices, are reflected from the walls to our ears. When we reach an open door, there isn't a wall for the sounds to bounce on. So what we hear by the open door is quite different. Try listening for this kind of sound clue. Use sound reflections to tell, for example, when you are near a wall or to tell whether you are in a large open space or in a small room.

(N remains at 12 o'clock) Let's experiment with turning your head for another point of view of sounds. Do you remember that I mentioned that front and back are hard to distinguish without a little movement of the head? Well, try this. I am speaking from 12 o'clock. My voice should seem centered. You might even think I was at 6 o'clock.

When I say "turn," you are to turn your head to face 1 o'clock a little to your right. Then when I say "turn back," you are to turn your head back. Are you ready?

Turn! (Mikes are turned right to face 10 o'clock) How do I sound? (N sounds as if he were at 11 o'clock) Turn back! (Mikes are turned back) You know now for a fact that I have been at 12 o'clock, not at 6 o'clock. If a person can't tell where a sound is coming from he usually moves his head slightly. Then what he hears combined with the feeling of what his head is doing helps him to locate sounds.

To use hearing most effectively one has to practice listening. Pay close attention to what you hear everyday so that your hearing will be more useful to you.

This is the end of this recording.

IN THE KITCHEN

RECORDING #8

(Position of Mike in the kitchen -- on cabinets with stove at 12 o'clock, sink at 2 o'clock, refrigerator in hall at 3 o'clock, table at 12 o'clock close to Mike, shelves where sugar is at 10 o'clock. Narrator at 10 o'clock always speaks directly toward mikes and in stationary position unless otherwise directed.)

NARRATOR: This is a recording In the Kitchen. It is a recording of familiar kitchen sounds. It will give you practice in identifying and localizing these sounds. You will have to imagine yourself in the center of the imaginary clock-face -- 12 o'clock directly in front of you, 6 o'clock directly behind; 3 o'clock to your right, 9 o'clock to your left. You are seated at the kitchen table. I am across the kitchen from you standing at the 10 o'clock position. The sounds you hear will be from the semi-circle in front of you. Of course, some sounds will be coming from directly at your sides. A "Friend" will make some instant coffee for us. As we proceed, follow the sounds by pointing in their direction. That will help. Of course, don't turn your head or the sound world will turn with you. Close your eyes if you are sighted at all and really imagine the situation.

("Friend," F performs actions) The sink is at 2 o'clock. Listen to the water running into the sink and then into the kettle. (Action) That was at 2 o'clock. Now the kettle must be returned to the stove at 12 o'clock and the click is heard as the electric burner is turned on. (Action) If there were a gas stove you would listen for the sound of gas escaping and then the burner lighting. You might hear a match for lighting the stove also. (F lights match and blows it out.)

We need a table cloth from a drawer at 1 o'clock. (F gets cloth from a drawer filled with cloth things.) That was a wooden drawer. (F puts cloth on table.) What was that? The cloth was put on the table in front of you.

Now for the cups and saucers from the cabinet at 3 o'clock. (F takes three cups and saucers from cabinet, places them -- saucer first, then cup -- before Mikes, then before N's place across the table, then for F at 11 o'clock. The saucers and cups were set before you at 12 o'clock, at my place, also at 12 o'clock, and at 11 o'clock where our friend will sit.

We need spoons, too. The silver drawer is at 3 o'clock beneath the china-cabinet. Listen. (F gets spoons, puts them down for Mike, N, then F.)

The cream is in the refrigerator at 9 o'clock. (F takes cream pitcher from refrigerator and places it in center of table.)

The sugar bowl and instant coffee jar are on the shelves beside me here at 10 o'clock. (F gets sugar and coffee and puts sugar beside the cream.)

(F unscrews jar lid and puts instant coffee in cups for Mike, for N, then for F) Did you identify sounds? Our friend opened the jar of coffee and put it into our cups -- yours, mine, and then hers. (F puts jar and spoon on table) Then she put the jar and spoon on the table in front of you -- at 12 o'clock.

The water is beginning to boil now at 12 o'clock. The stove must be turned off, the water poured into our cups and the kettle returned to the stove. (F clicks off the burner, gets kettle, and pours water into N's cup, F's cup, then Mike's cup; she returns kettle to stove.)

You cup was filled last. Could you tell whose was first? Mine. Now our coffee is ready.

We can sit down now. (Narrator and Friend pull out chairs from the table and sit.)

(Mike is in N's place; N is at 1 o'clock) Listen now to a few sounds as if you were sitting in my chair and I in yours. You will be in the center of the small kitchen. Really imagine that you have moved to my chair. Sounds now may come from any direction.

The stove is now behind you at 6 o'clock. Listen as our friend turns it on. (F clicks burner on and off.) The drawer with the table cloths is at 8 o'clock. (F pulls out drawer and then closes it.) The silver drawer is now at 10 o'clock. (F moves to silver drawer, takes out spoons, and recloses the drawer.) The cabinet where the china is kept is also at 10 o'clock. The refrigerator is at 2 o'clock. Our friend must walk back of you to the other side of the room. (F moves to refrigerator, opens and closes the door.)

The shelves with the sugar bowl are at 3 o'clock. (F moves to shelves, takes sugar bowl off the shelf and sets it down again.) The sink is at 9 o' clock. Listen as our friend walks behind you again and turns on the water. (F crosses behind Mike, turns water on and off twice.)

Were you able to imagine yourself in the kitchen? These have been ordinary sounds. But with practice you know more and more about your world by using hearing. For example, you can make fine distinctions in sounds. Listen as our friend puts a saucer down on different surfaces.

First, the counter-top of linoleum over wood(Action)
Second, the porcelain of the sink (Action)
Third, the metal of the stove (Action)
Fourth, the wooden shelf (Action)

Can you tell the difference? Of course, the location of these gives you an added cue, but each surface is different. Try and see.

SELF TEST: First -- (F places saucer on shelf at 3 o'clock)
Second -- (F places saucer on stove at 6 o'clock)
Third --(F places saucer on sink at 9 o'clock)
Fourth -- (F places saucer on counter at 10 o'clock)

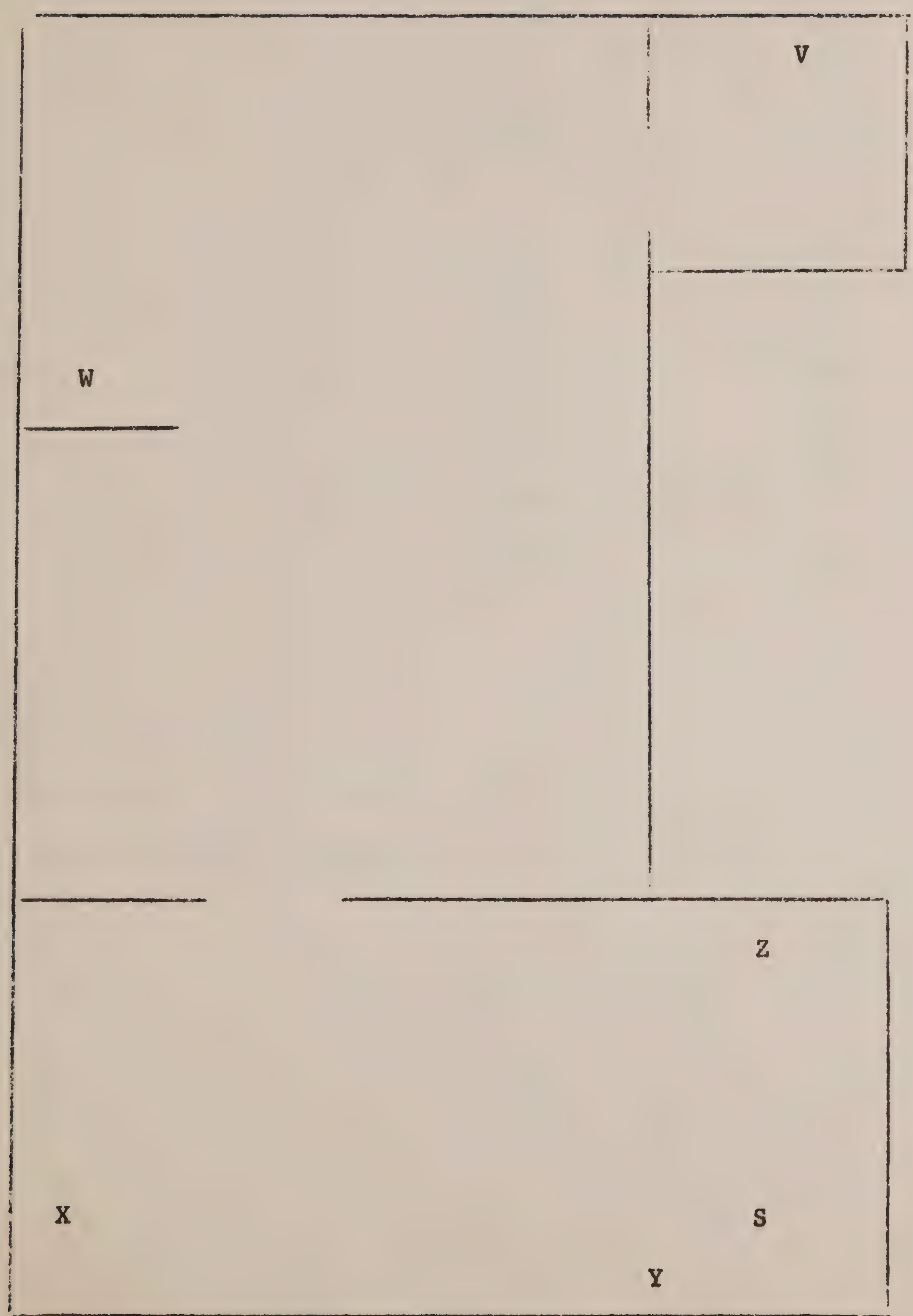
The correct answers are: first surface, the wooden shelf; second surface the metal of the stove; third, the sink; fourth, the linoleum top.

There are many distinctions in sound that you can make all the time. You often identify a familiar person by his walk. A woman's high heels are easy t spot. Listen for small differences in sounds from now on.

This concludes a recording <u>In the Kitchen</u>.

APPENDIX 4

MAZE OF ROOMS WITH SPEAKER LOCATIONS



MEAN TIME FOR EACH GROUP TO TRAVERSE EACH LEG OF THE MAZES

(In Seconds)

	LEG OF MAZE	EXPERIMENTAL GROUP	CONTROL GROUP	t
	S - Z	6.2	3.5	2.760*
	Z - X	8.1	5.6	2.308*
MAZE 1	X - W	23.1	16.2	2.291*
	W - V	19.9	12.4	2.848*
	V - W	16.6	9.5	3.381**
	W - Y	33.4	21.2	2.874*
	S - X	7.7	4.7	3.939**
	X - Y	8.4	4.9	3.783**
MAZE 2	Y - W	25.4	14.2	3.145**
	W - V	21.3	10.6	2.397*
	V - X	36.6	20.9	3.889**
	X - Z	9.6	5.4	4.327**

df = 18

N in each group = 10

* Significant at the 5% level

** Significant at the 1% level

APPENDIX 6

Means # of scores and standard deviations for each test for each group; the statistic <u>t</u> comparing mean scores of the trained (E) and untrained (C) groups on each of the five localization tests.

	E GROUP		C GROUP		
TEST	MEAN #	σ	MEAN #	σ	t
1	1.27	.346	.95	.390	1.839*
2	.98	.400	.92	.462	.294
3	.92	.310	.80	.200	[illegible]
4	1.01	.351	.93	.288	.530
5	.79	.263	.79	.382	.0387

Measure <u>b</u>, corrected mean clock-hour error (see text for explanation).

N = 10 for each mean.

* Significant at 10 per cent level.

APPENDIX 7

The statistic <u>t</u> comparing mean scores of the same group on Test I and each of the other four tests.

Comparisons of Corrected Error Means Between:	E Group <u>t</u>	C Group <u>t</u>
Tests 1 and 5	3.057***	2.319*
Tests 1 and 4	1.538	.225
Tests 1 and 3	2.381**	1.7503
Tests 1 and 2	1.883*	.248

*   Significant at 10 per cent level

**   Significant at 5 per cent level

*** Significant at 2 per cent level

ANALYSIS OF VARIANCE (MEASURE b)

SOURCE OF VARIATION	SS		df		MEAN SQUARE	F
Between method: E,C	.32		1		.3200	.9159
Between subjects in same group	6.29		18		.3494	
Total between subjects		6.61		19		
Between trials: I, II, III, IV, V	1.17		4		.2925	3.6746*
Interaction: Trials X Methods	.30		4		.0750	.9422
Interaction: Pooled Subjects X Trials	5.73		72		.0796	
Total within subjects		7.20		80		
Total SS		13.81		99		

* Significant at the 1 per cent level

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COMPARING PRETEST AND FINAL TEST

MEAN LOCALIZATION SCORES - AVERAGE CLOCK HOUR ERROR

		GROUP MEAN PRETEST	GROUP MEAN FINAL TEST	MEAN DIFFERENCE (IMPROVEMENT SCORE)	STANDARD ERROR OF THE DIFFERENCE	*t*
GROUP A	EARPHONE TEST	1.08	.59	.48	.0973	4.933**
GROUP A	SPEAKER TEST	.40	.24	.16	.0499	3.206**
GROUP B	EARPHONE TEST	1.11	.76	.36	.0763	4.718**
GROUP B	SPEAKER TEST	.37	.12	.25	.0674	3.709**

GROUP A -- Earphone trained (n = 11)

GROUP B -- Speaker trained (n = 12)

** Significant at the 1% level

COMPARING PRETEST AND FINAL TEST

MEAN LOCALIZATION SCORES - NUMBER CORRECT

GROUP		GROUP MEAN PRETEST	GROUP MEAN FINAL TEST	MEAN DIFFERENCE (IMPROVEMENT SCORE)	STANDARD ERROR OF THE DIFFERENCE	t
GROUP A	EARPHONE TEST	5.	6.64	1.64	.7229	2.269*
	SPEAKER TEST	9.82	10.82	1.00	.5559	1.798#
GROUP B	EARPHONE TEST	6.08	6.00	-.08	.5441	.1470
	SPEAKER TEST	9.67	12.25	2.58	.6450	4.000**

GROUP A -- Earphone trained (n = 11)

GROUP B -- Speaker trained (n = 12)

* Significant at the 5% level

** Significant at the 1% level

\# Approaches the 10% level of significance; for a df of 10, 1.812 is the 10% level.

COMPARING MEANS OF THE TWO GROUPS ON EACH TYPE OF TEST AND EACH MEASURE*

	TEST AND TYPE OF MEASURE COMPARED	GROUP A (EARPHONE TRAINED) MEAN	GROUP B (SPEAKER TRAINED). MEAN	STANDARD ERROR	t
NUMBER CORRECT	PRETEST ON SPEAKERS; NUMBER CORRECT	9.82	9.67	.7874	.191
	FINAL TEST ON SPEAKERS; NUMBER CORRECT	10.82	12.25	.8442	1.694
	PRETEST ON EARPHONES; NUMBER CORRECT	5.00	6.08	.5534	1.952
	FINAL TEST ON EARPHONES; NUMBER CORRECT	6.64	6.00	.9664	.662
AVERAGE ERROR	PRETEST ON SPEAKERS; AVERAGE ERROR	.40	.37	.0816	.368
	FINAL TEST ON SPEAKERS; AVERAGE ERROR	.24	.12	.2414	.497
	PRETEST ON EARPHONES; AVERAGE ERROR	1.08	1.11	.1321	.227
	FINAL TEST ON EARPHONES; AVERAGE ERROR	.59	.76	.1051	1.618

df = 21

* None are statistically significant!

FREQUENCY OF FRONT-BACK REVERSALS

	EARPHONE PRETEST	EARPHONE FINAL TEST
GROUP A (EARPHONE TRAINED) (N = 11)	23	2
GROUP B (SPEAKER TRAINED) (N = 12)	26	6
TOTALS	49	8

Shows the rapid improvement of ability to imagine the situation "to the front" or "to the back;" shows increased facility of the use of earphones and binaural recordings.

DATE DUE	BORROWER'S NAME
~~6-28-70~~	~~C. Culpepper~~
B. 5/3/74	Clark
~~2/14/78~~	~~Bukowity~~